

1 CLAIMS

2

3 1. A method of assessing eye function, comprising:

4 (a) providing an image area in which images
5 can be presented to the eye, and in which
6 the luminance of any point in the image
7 area over the desired field of view under
8 test can be defined at least as accurately
9 as the desired accuracy of a retinal map
10 to be obtained;

11 (b) forming a fixation image;

12 (c) presenting a stimulus to the eye at a
13 location within the image area spaced from
14 the fixation image;

15 (d) detecting a saccade triggered by said
16 stimulus and immediately removing the
17 original fixation image and creating a new
18 fixation image at said location;

19 (e) recording the timing and magnitude of the
20 saccade and the subsequent fixation;

21 (f) repeating steps (c) to (e); and

22 (g) comparing the results with a database of
23 typical eye responses.

24

25 2. The method of claim 1, further including
26 determining the location of the subject's head
27 relative to the image in at least the z-axis,
28 without applying any constraint to the head
29 motion.

30

31 3. The method of claim 1 or claim 2, in which each
32 of the fixation images is an animated fixation

1 image comprising a substantially stationary
 2 central region comprising at least 20% of the
 3 fixation image and a mobile perimeter defined
 4 such that the perimeter is greater than 3% of
 5 the arc of vision of the test subject in
 6 diameter.

7
 8 4. The method of any preceding claim,
 9 including the step of calculating the time
 10 T between the commencement of a stimulus
 11 point and the resulting saccade of the eye
 12 to said stimulus expressed by the
 13 function

14 Eq1:

$$T = \frac{(t^2 \cdot l + P)}{(t \cdot l)}$$

15
 16
 17

18 where t is the total time for the luminance "l"
 19 to integrate to the detection threshold of the
 20 retina and P is the Pullfrich delay for an
 21 arbitrarily chosen luminance "h" where $h = t \cdot l$.

22

23 5. The method of claim 4, in which t is derived
 24 from the function:

25 Eq2:

$$\left[\frac{-1}{(2 \cdot l)} \cdot \left(-T \cdot l + \sqrt{T^2 \cdot l^2 - 4 \cdot l \cdot P} \right) \right] \\ \left[\frac{-1}{(2 \cdot l)} \cdot \left(-T \cdot l - \sqrt{T^2 \cdot l^2 - 4 \cdot l \cdot P} \right) \right] = t$$

26
 27

- 1 6. The method of claim 5, in which a software
2 algorithm is used to solve Equation 2 and use
3 the greater of the two results as the total
4 amplified value sensitivity of a given retinal
5 point whereby relative sensitivity of the
6 retina from one point to another is expressed
7 directly as a function of t and can be derived
8 by the software from the interval time T .
9
- 10 7. The method of any of claims 4 to 6, in which
11 the intensity of "l" is adjusted to vary the
12 resolution of the measurement.
13
- 14 8. The method of claim 7, in which "l" is adjusted
15 to give an average saccade time of between 200
16 and 800 ms for maximum comfort and accuracy.
17
- 18 9. The method of any of claims 4 to 8, in which
19 the resulting value of "t" is used directly to
20 plot a relative sensitivity map of the retina.
21
- 22 10. The method of any of claims 4 to 9, in which a
23 software algorithm is provided to translate the
24 relative values of T to commonly used units of
25 measure of the retinal threshold sensitivity by
26 look up table or direct function based on the
27 Blondel-Rey law or Bloch's law.
28
- 29 11. The method of any of claims 4 to 10, in which
30 the stimulus can be increased or decreased in
31 brightness from its initial presentation
32 brightness during presentation, such an

1 increase or decrease being used to modify the
2 function of T to t to make the resulting
3 function either more or less linear whereby to
4 maintain the overall test speed at a rate most
5 comfortable to the patient.

6

7 12. The method of any of claims 4 to 11, in which
8 several images are simultaneously presented of
9 a resolution of less than 0.3 degrees only
10 resolvable by the fovea, such that the eye is
11 induced to sequentially saccade at the natural
12 saccade frequency of the patient's natural
13 visual scanning mode.

14

15 13. The method of claim 12, in which the value of
16 "1" is selected to induce a saccade frequency
17 close to the said natural scanning mode.

18

19 14. The method of any preceding claim, in
20 which a sequence of visual stimuli is
21 presented in said image area in a random
22 or pseudo random sequence such that the
23 position and preferably the expected time
24 of appearance of the next stimulus in a
25 sequence is not readily apparent to a
26 person viewing the display.

27 15. The method of any preceding claim, in which the
28 timing information is compared to a database of
29 timings for a population of humans of various
30 ages such that the integrated timings of T can
31 be compared to an average population of the

1 same age as the patient under test such that
2 the said value of T can be assigned the value
3 of zero.

4
5 16. The method of claim 15, in which the timing
6 information is compared with a further model of
7 the relative normal values of integral T over
8 the full area of the retina such that the
9 normal variations of the retinal sensitivity
10 with respect to angle from fovea may be
11 corrected to zero such that any deviation from
12 the norm will be represented as positive or
13 negative values relative to the normal value.

14
15 17. The method of any preceding claim, in which
16 there are displayed images containing a known
17 priority sequence of predictable fixation
18 points at separations of greater than 10
19 degrees of approximately half or less the
20 average brightness of the image and where at
21 least one region contains a further sub-image
22 of a recognizable structure or alphanumeric
23 character or pictorial representation of an
24 object with a resolution of approximately 0.25
25 degrees per cycle; and in which an alarm or
26 notification is delivered when more than one
27 sequence of saccades of sub 100ms and greater
28 than 10 degrees occurs per overall image and
29 records the overall time of the sequence of sub
30 100mS saccades.

1 18. The method of claim 17, in which said image is
2 a cartoon character, an animal picture, a
3 vehicle, or a personality.
4

5 19. The method of claim 17 or claim 18, in
6 which the threshold of 100mS is varied to
7 accommodate intoxicated, brain-damaged or
8 other abnormal patients based on an
9 average timing of a sequence of single
10 region of interest images as the norm for
11 a given intoxication, brain impairment or
12 other abnormality.

13 20. The method of any of claims 17 to 19, in
14 which the images are part of a video or
15 moving film sequence.

16 21. The method of claim 20, in which the
17 initial fixation cue comprises the
18 termination of motion of an image that
19 induces the eye pursuit of said image.

20 22. The method of claim 1, in which the image
21 contains a moving stimulus traveling
22 across the display and where a sub-image
23 of high detail only capable of
24 discrimination by the fovea is presented
25 for a period adjustable between 100-600mS
26 within a given time of the presentation of
27 a simple bright stimulus on the opposite
28 point of an axis drawn through the moving
29 stimulus, said given time being shorter
30 than the time required by the subject to

1 saccade to the simple stimulus and back to
2 the complex stimulus, preferably 50ms.

3

4 23. The method of claim 1 or claim 2, in which the
5 first fixation image is formed by a dark area
6 to which the eye is drawn by an image area
7 giving an impression of perspective, and in
8 which at least the first stimulus is formed by
9 an image area of high spatial frequency.

10

11 24. Apparatus for use in assessing eye function,
12 comprising:

13 (a) display means for presenting images to the
14 eye where the luminance of any point in the image
15 over the desired field of view under test can be
16 defined at least as accurately as the desired
17 accuracy of a retinal map to be obtained;

18 (b) means for generating on the display means
19 an initial fixation image;

20 (c) means for generating a stimulus on the
21 display means at a location spaced from the fixation
22 image;

23 (d) means for detecting a saccade triggered by
24 said stimulus and immediately removing the initial
25 fixation image and creating a new fixation image at
26 said location;

27 (e) means for recording the timing and
28 magnitude of each saccade and subsequent fixation
29 and for comparing the results with a database of
30 typical eye responses.

31

1 25. Apparatus according to claim 24, further
2 including means for determining the location of
3 the subject's head relative to the image in at
4 least the z-axis, without applying any
5 constraint to the head motion.

6
7 26. Apparatus according to claim 24 or claim 25, in
8 which each of the initial and subsequent
9 fixation images is an animated image comprising
10 a substantially stationary central region
11 comprising at least 20% of the fixation image
12 and a mobile perimeter defined such that the
13 perimeter is greater than 3% of the arc of
14 vision of the test subject in diameter.

15
16 27. Apparatus according to any of claims 24 to
17 26, including calculating means for
18 calculating the time T between the
19 commencement of a stimulus point and the
20 resulting saccade of the eye to said
21 stimulus expressed by the function

22 Eq1:

$$T = \frac{(t^2 \cdot l + P)}{(t \cdot l)}$$

23
24

25 where t is the total time for the luminance "l" to
26 integrate to the detection threshold of the retina
27 and P is the Pullfrich delay for an arbitrarily
28 chosen luminance "h" where $h = t \cdot l$.

29

1 28. Apparatus according to claim 27, in which the
 2 calculating means operates to derive t from the
 3 function:

4 Eq2:

$$5 \quad \left[\begin{array}{l} \frac{-1}{(2 \cdot l)} \cdot \left(-T \cdot l + \sqrt{T^2 \cdot l^2 - 4 \cdot l \cdot P} \right) \\ \frac{-1}{(2 \cdot l)} \cdot \left(-T \cdot l - \sqrt{T^2 \cdot l^2 - 4 \cdot l \cdot P} \right) \end{array} \right] = t$$

6

7 29. The apparatus of claim 28, in which a software
 8 algorithm is used to solve Equation 2 and use
 9 the greater of the two results as the total
 10 amplified value sensitivity of a given retinal
 11 point whereby relative sensitivity of the
 12 retina from one point to another is expressed
 13 directly as a function of t and can be derived
 14 by the software from the interval time T .

15

16 30. Apparatus according to any of claims 27 to 29,
 17 including means for adjusting the intensity of
 18 " l " to vary the resolution of the measurement.

19

20 31. Apparatus according to claim 30, in which " l "
 21 is adjusted to give an average saccade time of
 22 between 200 and 800 ms for maximum comfort and
 23 accuracy.

24

25 32 Apparatus according to any of claims 27 to 31,
 26 including means for plotting a relative
 27 sensitivity map of the retina directly from the
 28 resulting value of " t ".

29

- 1 33. Apparatus according to any of claims 27 to 32,
2 in which a software algorithm is provided to
3 translate the relative values of T to commonly
4 used units of measure of the retinal threshold
5 sensitivity by look up table or direct function
6 based on the Blondel-Rey law or Bloch's law.
7
- 8 34. Apparatus according to any of claims 27 to 33,
9 in which the means for generating a stimulus is
10 arranged to increase or decrease the
11 brightness of the stimulus from its initial
12 presentation brightness during presentation,
13 such an increase or decrease being used to
14 modify the function of T to t to make the
15 resulting function either more or less linear
16 whereby to maintain the overall test speed at a
17 rate most comfortable to the patient.
18
- 19 35. Apparatus according to any of claims 24 to 34,
20 in which the image display means is adapted to
21 display several images are simultaneously of a
22 resolution of less than 0.3 degrees only
23 resolvable by the fovea, such that the eye is
24 induced to sequentially saccade at the natural
25 saccade frequency of the patient's natural
26 visual scanning mode.
27
- 28 36. Apparatus according to any of claims 24 to 35,
29 in which the stimulus generating means is
30 arranged to present a sequence of visual
31 stimuli in said image area in a random or
32 pseudo random sequence such that the position

1 and preferably the expected time of appearance
2 of the next stimulus in a sequence is not
3 readily apparent to a person viewing the
4 display.

5
6 37. Apparatus according to any of claims 27 to 34
7 including a database of timings for a
8 population of humans of various ages, and
9 including means for comparing measured timing
10 information with the database such that the
11 integrated timings of T can be compared to an
12 average population of the same age as the
13 patient under test such that the said value of
14 T can be assigned the value of zero.

15
16 38. Apparatus according to claim 37, in which the
17 timing information is compared with a further
18 model of the relative normal values of integral
19 T over the full area of the retina such that
20 the normal variations of the retinal
21 sensitivity with respect to angle from fovea
22 may be corrected to zero such that any
23 deviation from the norm will be represented as
24 positive or negative values relative to the
25 normal value.

26
27 39. Apparatus according to any of claims 24 to 38,
28 in which the image display means is operative
29 to display images containing a known priority
30 sequence of predictable fixation points at
31 separations of greater than 10 degrees of
32 approximately half or less the average

1 brightness of the image and where at least one
2 region contains a further sub-image of a
3 recognizable structure or alphanumeric
4 character or pictorial representation of an
5 object with a resolution of approximately 0.25
6 degrees per cycle; and in which an alarm or
7 notification is delivered when more than one
8 sequence of saccades of sub 100ms and greater
9 than 10 degrees occurs per overall image and
10 records the overall time of the sequence of sub
11 100ms saccades.

12
13 40. Apparatus according to claim 39, in which the
14 threshold of 100mS is varied to accommodate
15 intoxicated, brain-damaged or other abnormal
16 patients based on an average timing of a
17 sequence of single region of interest images as
18 the norm for a given intoxication, brain
19 impairment or other abnormality.

20
21 41. Apparatus according to claim 24, in which the
22 image display means is operative to display an
23 image which contains a moving stimulus
24 traveling across the display and where a sub-
25 image of high detail only capable of
26 discrimination by the fovea is presented for a
27 period adjustable between 100-600mS within a
28 given time of the presentation of a simple
29 bright stimulus on the opposite point of an
30 axis drawn through the moving stimulus, said
31 given time being shorter than the time required
32 by the subject to saccade to the simple

1 stimulus and back to the complex stimulus,
2 preferably 50ms.

3

4 42. Apparatus according to claim 24 or claim 25, in
5 which the first fixation image is formed by a
6 dark area to which the eye is drawn by an image
7 area giving an impression of perspective, and
8 in which at least the first stimulus is formed
9 by an image area of high spatial frequency.

10

11 43. A software package containing data
12 enabling the essential timing, control and
13 display mechanisms for carrying out the
14 method of any of claims 1 to 23 using
15 commercially available display, camera and
16 measurement devices..